Bilateral internal thoracic artery grafting in diabetic patients: Short-term and long-term results of a 515-patient series

Oren Lev-Ran, MD^a
Rephael Mohr, MD^a
Dmitri Pevni, MD^a
Nahum Nesher, MD^a
Yona Weissman, BA^b
Dan Loberman, MD^a
Gideon Uretzky, MD

Background: Despite potential long-term benefits, bilateral internal thoracic artery grafting in diabetics remains controversial because of the risk of sternal infection. We sought to assess the short- and long-term outcome after left-sided bilateral internal thoracic artery grafting and to determine the configuration of choice in diabetic subsets.

Methods: Between 1996 and 2001, 515 diabetics underwent isolated left-sided skeletonized bilateral internal thoracic artery grafting. The outcome of 468 consecutive oral-treated diabetics and 47 selective insulin-treated patients was analyzed. Patients undergoing T-grafting were compared with those undergoing in situ bilateral internal thoracic artery arrangements.

Results: The respective rates for early mortality and sternal infections were 2.4% and 1.9% in oral-treated diabetics and 6.3% and 4.3% in insulin-treated diabetics. Multivariate correlates of sternal infection were chronic lung disease (odds ratio, 10), obesity (odds ratio, 7), reoperation (odds ratio, 22), and a creatinine level of 2 mg/dL or more (odds ratio, 8). Five-year survival was 82%. The T-graft (n = 437) and in situ (n = 162) subgroups had comparable baseline profiles. Freedom from cardiac mortality at 6.5 years was 95.6% and 87.6% ($P = .277$), and freedom from repeat revascularization was 91.5% and 92.7% ($P = .860$), respectively. The choice of bilateral internal thoracic artery configuration did not appear as a correlate of mortality, cardiac mortality, or major adverse cardiac events. Complementary right-sided gastroepiploic artery (hazard ratio, 0.36) and sequential (hazard ratio, 0.55) grafting were identified as protective factors against the occurrence of major adverse cardiac events.

Conclusions: Routine skeletonized bilateral internal thoracic artery grafting can be implemented safely in oral-treated diabetics. This strategy is associated with a favorable late cardiac outcome and is thus recommended. Both left-sided bilateral internal thoracic artery configurations provide comparable short- and long-term outcomes.

From the Department of Cardiothoracic Surgery^a and the Statistical Service,^b Tel Aviv Sourasky Medical Center, Tel Aviv, Israel.

Received for publication June 11, 2003; revisions requested Sept 18, 2003; revisions received Oct 3, 2003; accepted for publication Oct 7, 2003.

Address for reprints: Oren Lev-Ran, MD, Department of Cardiac and Thoracic Surgery, The Tel Aviv Sourasky Medical Center, 6 Weizman St, Tel Aviv 64239, Israel (E-mail: orenlevran@hotmail.com).

J Thorac Cardiovasc Surg 2004;127:1145-50
0022-5223/\$30.00

Copyright © 2004 by The American Association for Thoracic Surgery

doi:10.1016/j.jtcvs.2003.10.012

Subgroup analysis of the Bypass Revascularization Investigation identified coronary artery bypass grafting (CABG) as the preferred method of myocardial revascularization in diabetics.¹ These findings were corroborated by subsequent trials.²⁻⁶ An increasing number of patients undergoing CABG are diabetics.⁷ Nevertheless, reflecting accelerated atherosclerosis, diabetic patients are at a higher risk for long-term mortality and have an increased propensity for bypass graft failure in comparison to

nondiabetics.^{6,8} Thereby, diabetic patients may benefit from a CABG, which is most resistant to the enhanced atherosclerotic process.

The superiority of the internal thoracic artery (ITA) over other conduits has been established. Comparative studies have demonstrated improved resistance to the development of atherosclerosis, intimal hyperplasia, and medial calcification^{9,10} and maintained vasoreactive properties despite long-term diabetes.¹¹ From a clinical standpoint, ITA use has been recognized as a strong predictor of survival in diabetic patients undergoing myocardial revascularization.^{1,3} Although left-sided bilateral ITA (BITA) grafting is associated with improved survival, event-free survival, and freedom from repeat revascularization in the general population,¹² the application of this strategy in diabetics remains controversial because of the risk of sternal infection and subsequent lethal mediastinitis.¹³ To date, analysis of small datasets did not offer a clear mandate for routine BITA use in diabetics, and its long-term benefits in this group remain unclear.

Recently, skeletonized ITA harvesting¹⁴ and modifications in perioperative glucose management¹⁵ were shown to attenuate the risk of sternal infection. Reduced sternal devascularization was shown after skeletonized ITA mobilization.¹⁶

This study was designed to evaluate the risk of routine BITA grafting in diabetics. Secondary goals were to assess the long-term outcome after this strategy and to determine the left-sided BITA configuration of choice.

Methods

Patient Population

Between April 1996 and October 2001, 515 consecutive diabetic patients underwent isolated CABG with skeletonized BITA. This group comprised 30% of all BITA grafting performed during this period. Included in the study were diabetic patients receiving oral-agent or insulin treatment before the index operation. Diabetics managed with diet only were excluded.

Since 1996, we have not declined the use of skeletonized BITA in diabetic patients. All oral-treated diabetics have been regarded as eligible for BITA grafting. Excluded were patients undergoing emergency operations, patients with chronic obstructive pulmonary disease (COPD; including chronic bronchitis, emphysema, and bronchial asthma), and women with a body mass index (BMI) of 30 kg/m² or more. Diabetics with these associated conditions, which are included in this report, were among the first enrollees who were recruited before data on their risk appeared.¹⁴ These guidelines were similar to those applied for BITA grafting in nondiabetics during this time.¹⁷ Patients were excluded from BITA grafting only when they were considered at high risk for sternal infection (detailed criteria), irrespective of the patient's cardiac or other risk factors. Therefore, there was no selection bias in patient allocation to this technique. Conversely, among insulin-treated diabetics, BITA grafting was performed selectively; other than the aforementioned criteria, this was primarily based on the surgeon's

preference. Neurologically symptomatic patients or asymptomatic patients aged 65 years or older were routinely screened by carotid Doppler assays, and those who required carotid endarterectomy were excluded.

Surgical Technique

Operations were performed through a midsternotomy by using standard cardiopulmonary bypass or off-pump coronary artery bypass (OPCAB). Myocardial preservation during CPB involved intermittent, antegrade, or retrograde blood cardioplegia (30°C–32°C). Coronary stabilization during OPCAB was facilitated by use of CTS stabilizers (Curpentino, Calif) or the Octopus system (Medtronic, Minneapolis, Minn). ITAs were mobilized as skeletonized vessels.¹⁷ In all cases, BITA were used to graft the left coronary system, ie, the myocardial territory supplied by the left anterior descending and circumflex arteries. Two arrangements were implemented: (1) free right ITA attached proximally on the left ITA in a T-graft configuration and (2) in situ BITA with an anteaortic crossover right ITA.¹⁷ The choice of configuration was determined by previously detailed technical considerations¹⁷ and was irrespective of the diabetic status. In case supplemental grafts to the right coronary system were necessary, the in situ right gastroepiploic artery (GEA) or saphenous vein was used. The type of conduit selected was based on the surgeon's preference; however, use of the GEA required stenosis more than 70% of the target vessel.

Preoperative and Postoperative Management

On admission, glucose levels were managed by continuing the patient's regimen with additional sliding-scale–guided intermittent subcutaneous insulin injections aimed at achieving serum glucose levels of 250 mg/dL or less. Postoperative treatment included intravenously administered isosorbide dinitrate (4 to 20 mg/h) for 2 days, and patients who received GEA grafts were treated with calcium channel blockers for 6 months. Glucose management was initially aimed at blood glucose levels of 250 mg/dL or less by using intermittent insulin injections and renewal of oral medication by the second postoperative day. After February 2000, glucose management was modified, and continuous intravenous insulin was administered for 48 postoperative hours to achieve target levels of 200 mg/dL or less.¹⁵ Postoperative angiography was performed selectively only in symptomatic patients (return of angina or undetermined chest pain) or in those with a positive radionuclear scan.

Definitions and Data Collection

Patients' data were analyzed according to the Society of Thoracic Surgeons National Cardiac Surgery Database guidelines and definitions. Causes of death were classified as cardiac or noncardiac. Cardiac mortality was defined as death occurring in relation to myocardial infarction (MI), cardiac arrhythmia, out-of-hospital sudden death, or deteriorating congestive heart failure. Undetermined causes of death were regarded as cardiac. Major adverse cardiac events (MACE) were defined as the occurrence of a nonfatal MI, the need for repeat revascularization, or cardiac mortality. Follow-up was obtained by a telephone questionnaire and the national registry database.

Data Analysis

Data are expressed as mean $\pm$ SD. The χ^2 test and Fisher exact test were used to compare discrete variables. Actuarial survival and event-free survival curves were obtained with the Kaplan-Meier method. Statistical significance was calculated with the log-rank test. Cox analysis was used to evaluate the influence of preoperative and operative variables on late survival, freedom from cardiac mortality, and freedom from MACE. Logistic regression was used to evaluate the effect of preoperative and operative descriptors on the occurrence of sternal infection. Results of logistic regression are expressed as odds ratios (OR) with associated 95% confidence intervals (CI) and *P* values. Results of Cox analysis are expressed as hazard ratios (HR), 95% CI, and *P* values. All analyses were performed with SPSS 9 software (SPSS Inc, Chicago, Ill).

Results

The oral-treated diabetic group constituted 80% of all oral-treated diabetics who underwent isolated CABG during this period. Among the 515 study diabetics, there were 468 (90.9%) oral-treated patients and 47 (9.1%) insulin-treated diabetics. Patients received 2 to 6 grafts (mean, 3), and the ITA graft to patient ratio was 2.6 (overall, 1335 distal ITA anastomoses were performed). Total arterial grafting was achieved in 78% of operations. Details are listed in Table 1.

Early and late outcome are detailed in Table 2. The observed 30-day mortality in the oral-treated group (2.4%) was significantly lower than the predicted Euroscore (standard, 5.9%; logistic, 0.07; 95% CI, 0.061-0.077). Conversely, the 6.3% observed mortality for insulin-treated patients was slightly higher than predicted (standard, 5.8%; logistic, 0.06; 95% CI, 0.042-0.083). The major cause of 30-day mortality among oral-treated diabetics was cardiac (58%), followed by neurologic, infectious, and renal causes (14% each). Causes of death in the insulin-treated group were cardiac, complicated renal failure, and sepsis (1 patient each). The incidence of sternal infection was 1.9% and 4.3% in the oral-treated and insulin-treated subgroups, respectively.

Patients were compared on the basis of the configuration of BITA grafting (T-graft vs in situ). The baseline profile and operative data were similar, with the exception of more grafts and sequential anastomoses in the T-graft subgroup and more OPCAB performed in the in situ subgroup (Table 3). Early results were comparable (Table 4).

Follow-up

Follow-up ranged from 6 to 79 months (average, 42 months) and was ascertained for 98% of the patients. Late results are listed in Tables 2 and 4. A total of 109 (8.2%) distal ITA anastomoses were demonstrated angiographically (15 to 66 months after surgery; median: 40 months) with a patency rate of 92%. All 27 (6.2%) T-anastomoses demonstrated were patent. By 6.5 years, 22 (4.3%) repeat angioplasties and 2 (0.4%) redo CABG operations had been performed

TABLE 1. Baseline characteristics and operative data

Factor	Oral-treated (n = 468) (%)	Insulin-treated (n = 47) (%)	Total (n = 515) (%)
Age (y)*	66.4 $\pm$ 9.3	64.4 $\pm$ 9.6	66.2 $\pm$ 9.3
Age $\geq$ 75 y	17.6	21.3	17.6
Female sex	30.1	38.3	30.9
Body mass index >30 kg/m ²	7.7	12.8	8.2
Peripheral vascular disease	15	34	16.7
Hyperlipidemia	48.4	44.7	48.1
Chronic lung disease	6.2	2.1	5.8
Serum creatinine >2 mg/dL	3.8	8.5	4.3
Prior neurologic events	8.8	0	8
Acute MI <1 wk	17.9	6.4	16.9
Congestive heart failure	18.2	23.4	18.6
Ejection fraction $\leq 35\%$	8.3	8.5	8.3
Prior angioplasty	14.1	29.8	15.6
Left main disease	28.8	27.7	28.7
3-Vessel disease	80	91	81
2-Vessel disease	20	9	10
Intra-aortic balloon	3.4	2.1	3.3
Emergency surgery	7.1	2.1	6.6
Redo CABG	1.5	2.1	1.6
Mean grafts per patient*	3.1 $\pm$ 0.84	2.7 $\pm$ 0.72	3 $\pm$ 0.83
Sequential grafts	51.5	34	49.9
T-grafts	68.6	63.8	68.3
Use of GEA	19.7	21.3	19.8
Use of saphenous vein	22.3	14.9	21.6
Bypass time (min)*	84 $\pm$ 33	70 $\pm$ 23	83 $\pm$ 32
Clamp time (min)*	72 $\pm$ 23	62 $\pm$ 21	71 $\pm$ 23
Off-pump	9.3	8.9	9.3

MI, Myocardial infarction; CABG, coronary artery bypass graft; GEA, gastroepiploic artery.

*Data are mean $\pm$ SD.

TABLE 2. Early and late* results

Variable	Oral-treated (n = 468) (%)	Insulin-treated (n = 47) (%)	Total (n = 515) (%)
30-d mortality	2.4	6.4	2.7
Q-wave MI	1.1	0	1
Neurologic complications	1.5	2.1	1.6
Deep sternal infection	1.9	4.3	2.1
Overall sternal complications	3.4	6.4	3.7
Late nonfatal MI	2.6	4.3	2.7
Repeat revascularization	4.1	10.6	4.7
MACE†	10.3	14.9	10.8
Late mortality	12.4	10.6	12.3
Late cardiac mortality	6	4.4	5.9

MI, Myocardial infarction; MACE, major adverse cardiac events.

*Late results were defined as events occurring between the 1st and 80th postoperative month.

†Occurrence of 1 or more of the following: late nonfatal MI, reintervention, or cardiac-related mortality.

(range, 15 to 68 months after surgery; median, 41 months). Eighteen of the 24 procedures were to non-ITA-grafted vessels, ie, nongrafted native arteries or non-ITA conduits.

TABLE 3. Baseline characteristics and operative data: patients are grouped on the basis of the left-sided bilateral internal thoracic artery configuration

Variable	In situ (n = 162) (%)	T-graft (n = 437) (%)	P value
Age (y)	65 ± 9	67 ± 9	.143
Female sex	30.2	31.4	.791
BMI ≥30 kg/m ²	7.4	8.6	.636
PVD	14.8	17.6	.436
Hyperlipidemia	52.8	46.4	.179
COPD	3.7	6.6	.185
Creatinine >2 mg/dL	2.5	5.2	.241
Neurologic events	6.8	8.4	.529
Acute MI	13	18.7	.106
CHF	19.8	17.6	.550
EF <35%	8	8.4	.899
Emergency operation	5.6	7.2	.488
Redo CABG	1.9	1.4	.713
Insulin treatment	10.5	8.6	.502
Grafts per patient	2.9 ± 0.9	3.2 ± 0.8	<.0001
Sequential anastomoses	34.6	57	<.0001
Supplemental GEA	17.3	21	.323
Supplemental SV	22.2	21.3	.819
Bypass time (min)	78 ± 29	80 ± 34	.494
Clamp time (min)	68 ± 21	73 ± 22	.189
Off-pump	21.6	3.5	<.001

BMI, Body mass index; PVD, peripheral vascular disease; COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; CHF, congestive heart failure; EF, ejection fraction; CABG, coronary artery bypass grafting; GEA, gastroepiploic artery; SV, saphenous vein.

TABLE 4. Early and late* results: patients are grouped on the basis of the left-sided bilateral internal thoracic artery configuration

Variable	In situ (n = 162) (%)	T-graft (n = 437) (%)	P value
30-d mortality	3.1	2.6	.755
Q-wave MI	1.2	0.9	.655
Neurologic events	1.9	1.4	.714
Deep sternal infection	1.9	2.3	.999
Overall sternal infection	4.3	3.5	.632
Return of angina	6.2	8.7	.322
Late nonfatal MI	1.9	3.2	.564
Repeat revascularization	4.4	5	.771
Late cardiac mortality	3.3	6.9	.116
MACE†	10.5	15	.168
Late mortality	10.6	12.9	.168

MI, Myocardial infarction; MACE, major adverse cardiac events.

*Late results were defined as events occurring between the 1st and 80th postoperative month.

†Occurrence of 1 or more of the following: late nonfatal MI, reintervention, or cardiac-related mortality.

Five-year survival was 82% for the oral-treated group and 84.7% for the selective insulin-treated group, respectively (Kaplan-Meier). Freedom from cardiac mortality at 1,

5, and 6.5 years was 99.5%, 91.4%, and 90%, respectively (Kaplan-Meier). At 6.5 years, freedom from nonfatal MI and freedom from repeat revascularization was 94% and 93% for the oral-treated patients and 93% and 82% for insulin-treated diabetics, respectively.

Comparison between the in situ and T-graft subgroups at 6.5 years showed comparable freedom from nonfatal MI (96% and 92%, respectively; $P = .514$; log rank) and freedom from repeat revascularization (91.5% and 92.7%; $P = .860$; log rank). Correspondingly, there was no difference in cardiac mortality (95.8% and 90%; $P = .277$; log rank) or MACE (86.2% and 80.5%; $P = .531$; log rank).

Analysis of Morbidity and Late Cardiac Outcome

Significant predictors of deep sternal infection were COPD ($P = .003$; OR, 10.6), BMI greater than 30 kg/m² ($P = .008$; OR, 7.0), female sex ($P = .022$; OR, 5.5), redo CABG ($P = .023$; OR, 22.7), and a serum creatinine level of 2 mg/dL or more ($P = .025$; OR, 8.2). The risk of obese women for the development of sternal infection was 22-fold ($P = .042$; OR, 22).

Predictors of late mortality, late cardiac mortality, and MACE are listed in Table 5. Sequential grafting ($P = .047$; HR, 0.55) and the use of supplemental right-sided GEA ($P = .028$; HR 0.36) were identified as protective factors against the occurrence of MACE. Sequential grafting also had a protective effect on cardiac mortality ($P = .093$; HR 0.49). The choice of left-sided BITA configuration (T-grafts or in situ) was not identified as a correlate of survival, late cardiac mortality, or the occurrence of MACE.

Discussion

The main finding of this study was that routine skeletonized BITA grafting can be implemented safely in oral-treated diabetics. This approach was associated with favorable late cardiac outcomes. Both configurations of left-sided BITA grafting—in situ and T-grafting—provided comparable short- and long-term results.

Small datasets of diabetics undergoing BITA grafting did not offer a clear mandate for routine use of this strategy. This analysis of a large diabetic cohort attempted to resolve this issue. Oral- and insulin-treated diabetics were analyzed separately. Whereas the former group presented consecutive patients with no selection bias, the use of BITA in insulin-treated diabetics was selective. Nevertheless, these data are presented because of their sparsity in the literature. The observed 1.9% incidence of sternal infections among oral-treated diabetics compares with that reported after single ITA mobilization in this diabetic subset.^{1,18,19} Multivariate analysis validated previous observations that identified COPD and obesity (BMI ≥30 kg/m²) as strong predictors of sternal infection.¹⁴ The combination of being obese, diabetic, and female increased the risk by 22-fold. Severe renal

TABLE 5. Cox analysis: independent risk factors for all-cause mortality, cardiac mortality, and MACE*

Variable	All cause mortality			Cardiac mortality			MACE		
	HR	95% CI	P	HR	95% CI	P	HR	95% CI	P
Age	1.056	1.019-1.095	.003	1.047	0.995-1.102	.080	0.977	0.947-1.007	.129
COPD	2.249	0.972-5.202	.058	2.613	0.810-8.424	.108	2.059	0.846-5.010	.112
EF <35%	1.207	0.510-2.857	.669	2.573	0.939-7.051	.066	1.281	0.532-3.083	.580
LM disease	1.640	0.941-2.857	.081	1.993	0.860-4.617	.108	1.499	0.816-2.753	.192
Sequential grafting	0.825	0.470-1.448	.503	0.490	0.213-1.126	.093	0.552	0.307-0.993	.047
Use of GEA	0.608	0.274-1.349	.221	0.634	0.202-1.993	.436	0.364	0.148-0.896	.028

HR, Hazard ratio; CI, confidence interval; COPD, chronic pulmonary disease; EF, ejection fraction; LM, left main coronary artery; GEA, gastroepiploic artery.

*Occurrence of 1 or more of the following: late nonfatal myocardial infarction, reintervention, or cardiac-related mortality.

dysfunction and redo CABG were further identified as correlates of sternal infection. It is our recommendation, therefore, that BITA grafting, irrespective of the mobilization technique, be avoided in these diabetic subsets. Time-frame analysis further showed that the incidence during the last 2 years was lower than in the preceding time period (1.4% vs 2.4%, respectively). This may reflect the learning curve associated with the skeletonization technique, the formation of eligibility criteria along the study,¹⁴ and adoption of a more vigilant policy of glucose control¹⁵ during this period. Evidently, this 3-armed strategy is associated with reproducible results.

The 30-day mortality (2.4%) among oral-treated diabetics was significantly lower than the Euroscore-predicted mortality and compares favorably with the 3.2% mortality in the corresponding Society of Thoracic Surgeons database oral-treated subgroup.²⁰

It has been postulated that long-term cardiac protection is provided only by arterial grafts, whereas venous conduits undergo pathophysiologic and clinical deterioration that is similar to that from native coronary disease.²¹ Recent interest has focused on the use of arterial conduits in diabetics^{5,19}; however, because surgeons are reluctant to use BITA in these patients, it may be that less-than-optimal alternative arterial grafts are used. The only conduit found to improve survival in diabetics is the ITA,^{1,3} and left-sided BITA grafting is the only recognized grafting pattern associated with improved survival in the general population.¹² This study focuses on left-sided BITA grafting in diabetics. Our results imply that this approach may confer cardiac benefits in diabetics as well. Taking into account that the ITA attrition rate is confined to the early postoperative years,²² the 4.7% repeat revascularization rate at 6.5 years seems favorable. Although angiograms were performed selectively in prone patients (symptomatic patients or those with positive radionuclear scan; see Methods), a 92% ITA patency rate was shown. Most repeat revascularizations were required because of non-ITA graft failure or progression of disease in nongrafted vessels. This may explain the low rate of re-CABG (0.4%), because patients with a dura-

ble patent left-sided BITA retain a survival benefit from the initial CABG and would have less of a benefit from reoperation. This should be viewed in the face of a recently reported 11% mortality in re-CABG in diabetics.²³ Further, the observed results (Table 2) should be viewed in face of the 11% repeat revascularizations at 7 years⁴ and 13% at 8 years⁶ reported with single ITA grafting or the 19% cardiac mortality in similar diabetic cohorts.⁶ Nevertheless, because this observational study does not include comparative data, the question of whether BITA grafting confers superior long-term outcome in comparison to other grafting strategies remains to be answered.

An additional conduit is often required to graft the right coronary territory when left-sided BITA is applied. In this study, the GEA or saphenous vein was used for this purpose. Complementary right-sided GEA was found by multivariate analysis to be associated with a reduced risk of MACE. This benefit was not apparent in a previous study conducted in the general population.²⁴ Sequential grafting also showed a protective tendency with regard to cardiac-related mortality. The benefits conferred by sequential anastomoses have been previously detailed.^{22,25}

The preferred BITA configuration remains controversial. Several clinical studies have demonstrated comparable results between in situ and T-grafts^{17,26}; however, incidental evidence suggest incomplete relief of ischemia after T-grafting.²⁷ It has been speculated that unique problems of T-grafts, such as competitive flow or limited flow reserve, might be exacerbated in diabetics secondary to enhanced atherosclerotic processes^{9,10} or altered vasoreactivity.¹¹ This study shows that the 2 techniques are comparable with regard to short- and long-term outcome. Also, the choice of BITA configuration was not identified as a correlate of mortality, cardiac mortality, or MACE. Therefore, the choice of technique should be primarily based on technical considerations during the operation.¹⁶

Several limitations of this study need to be addressed. It is a retrospective study, and a direct comparison with other conduits would be required to determine the long-term advantage of BITA in diabetic subsets. The small number of

insulin-treated patients and the low number of events negate definite conclusions with regard to the feasibility of BITA grafting in this subgroup.

In conclusion, routine skeletonized BITA grafting can be performed safely in oral-treated diabetics. This strategy is associated with favorable late cardiac outcome. Both left-sided BITA configurations (in situ and T-grafting) provide comparable short- and long-term outcome; therefore, the choice of technique should be based on technical considerations during the operation. Conclusions with regard to the safety of BITA grafting in insulin-treated diabetics should await further data.

References

- Comparison of coronary bypass surgery with angioplasty in patients with multivessel disease. The Bypass Angioplasty Revascularization Investigation (BARI) Investigators. *N Engl J Med*. 1996;335:217-25.
- Kurbaan AS, Bowker TJ, Ilsley CD, Sigwart U, Rickards AF. Difference in mortality of the CABRI diabetic and nondiabetic population and its relation to coronary artery disease and revascularization mode. *Am J Cardiol*. 2001;87:947-50.
- The BARI Investigators. Seven-year outcome in the Bypass Angioplasty Revascularization Investigation (BARI) by treatment and diabetic status. *J Am Coll Cardiol*. 2000;35:1122-9.
- King SB, Kosinski AS, Guyton RA, Lembo NJ, Weintraub WS. Eight-year mortality in the Emory Angioplasty versus Surgery Trial (EAST). *J Am Coll Cardiol*. 2000;35:1116-21.
- Abizaid A, Costa MA, Centemero M, Abizaid AS, Legrand VM, Limet RV, et al. Clinical and economic impact of diabetes mellitus on percutaneous and surgical treatment of multivessel coronary artery disease. Insights from the Arterial Revascularization Therapy Study (ARTS) trial. *Circulation*. 2001;104:553-8.
- Barsness GW, Peterson ED, Ohman EM, Nelson CL, DeLong ER, Reves JG, et al. Relationship between diabetes mellitus and long-term survival after coronary bypass surgery and angioplasty. *Circulation*. 1997;96:2551-6.
- Abraov D, Tamari MG, Fremes SE, Guru V, Borger MA, Christakis GT, et al. Trends in coronary artery bypass surgery results: a recent 9-year study. *Ann Thorac Surg*. 2000;70:84-90.
- Lawrie GM, Morris GC Jr, Glaeser DH. Influence of diabetes mellitus on the results of coronary bypass surgery. Follow-up of 212 diabetic patients ten to 15 years after surgery. *JAMA*. 1986;256:2967-71.
- Kaufer E, Factor SM, Frame R, Brodman RF. Pathology of radial artery and internal thoracic arteries used as coronary artery bypass grafts. *Ann Thorac Surg*. 1997;63:1118-22.
- Ruengsakulrach P, Sinclair R, Komeda M, Raman J, Gordon I, Buxton B. Comparative histopathology of radial artery versus internal thoracic artery and risk factors for development of intimal hyperplasia and atherosclerosis. *Circulation*. 1999;100(19 suppl):II139-44.
- Wendler O, Landwehr P, Bandner-Risch D, Geotg T, Schafers HJ. Vasoreactivity of arterial grafts in the patient with diabetes mellitus: investigations on internal thoracic artery and radial artery conduits. *Eur J Cardiothorac Surg*. 2001;20:305-11.
- Taggart DP, D'Amico R, Altman DG. Effect of arterial revascularization on survival: a systematic review of studies comparing bilateral and single internal mammary arteries. *Lancet*. 2001;358:870-5.
- Borger MA, Rao V, Weisel RD, Ivanov J, Cohen G, Scully HE, et al. Deep sternal wound infection: risk factors and outcomes. *Ann Thorac Surg*. 1998;65:1050-6.
- Matsa M, Paz Y, Gurevitch J, Shapira I, Kramer A, Pevny D, et al. Bilateral skeletonized internal thoracic artery grafts in patients with diabetes mellitus. *J Thorac Cardiovasc Surg*. 2001;121:668-74.
- Furnary AP, Zerr KJ, Grunkemeier GL, Starr A. Continuous intravenous insulin infusion reduces the incidence of deep sternal wound infection diabetic patients after cardiac surgical procedures. *Ann Thorac Surg*. 1999;67:352-60.
- Cohen AJ, Lockman J, Lorberboym M, Bder O, Cohen N, Medalion B, et al. Assessment of sternal vascularity with single photon emission computed tomography after harvesting of the internal thoracic artery. *J Thorac Cardiovasc Surg*. 1999;118:496-502.
- Lev-Ran O, Paz Y, Pevni D, Kramer A, Shapira I, Locker C, et al. Bilateral internal thoracic artery grafting: midterm results of composite versus in-situ crossover graft. *Ann Thorac Surg*. 2002;74:704-11.
- Detre KM, Guo P, Holubkov R, Califf RM, Sopko G, Bach R, et al. Coronary revascularization in diabetic patients: a comparison of randomized and observational components of the Bypass Angioplasty Revascularization Investigation (BARI). *Circulation*. 1999;99:633-40.
- Szabo Z, Hakanson E, Svedjeholm R. Early postoperative outcome and medium-term survival in 540 diabetic and 2239 nondiabetic patients undergoing coronary artery bypass grafting. *Ann Thorac Surg*. 2002;74:712-9.
- Carson JL, Scholz PM, Chen AY, Peterson ED, Gold J, Schneider SH. Diabetes mellitus increases short-term mortality and morbidity in patients undergoing coronary artery bypass graft surgery. *J Am Coll Cardiol*. 2002;40:419-23.
- Loop FD, Lytle BW, Cosgrove DM, Stewart RW, Goormastic M, Williams GW, et al. Influence of internal thoracic artery on 10 year survival and other cardiac events. *N Engl J Med*. 1986;314:1-9.
- Dion R, Glineur D, Derouck R, Verbelst R, Noirhomme P, El Khoury G, et al. Long-term clinical and angiographic follow-up of sequential internal thoracic artery grafting. *Eur J Cardiothorac Surg*. 2000;17:407-14.
- Cole JH, Jones EL, Craver JM, et al. Outcomes of repeat revascularization in diabetic patients with prior coronary surgery. *J Am Coll Cardiol*. 2002;40:1968-75.
- Vural KM, Sener E, Tasdenir O. Long-term patency of sequential and individual saphenous vein coronary bypass grafts. *Eur J Cardiothorac Surg*. 2001;19:140-4.
- Lev-Ran O, Mohr R, Uretzky G, Pevni D, Locker C, Paz Y, et al. Graft of choice to the right coronary system in left-sided bilateral internal thoracic artery grafting. *Ann Thorac Surg*. 2003;75:88-92.
- Calafiore AM, Contini M, Vitolla G, Di Mauro M, Mazzei V, Teodori G, et al. Bilateral internal thoracic artery grafting: long-term clinical and angiographic results of in-situ versus Y grafts. *J Thorac Cardiovasc Surg*. 2000;120:990-6.
- Sakaguchi G, Tadamura E, Ohnaka M, Tambara K, Nishimura K, Komeda M. Composite arterial Y graft has less coronary flow reserve than independent grafts. *Ann Thorac Surg*. 2002;74:493-6.